BEST AVAILABLE COPY

PCT/GB 2004 / 004952

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 24 December 2004

25NOV03 E854637-7 000027
P01/7700 0.00-0327310.9

Patents Form 1/77

Patents Act 1977
(Rule 16)

THE PATENT OFFICE
24 NOV 2003

The Patent Office

1/77

The Patent Office
Cardiff Road
Newport
South Wales
NP10 8QQ

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1.	Your reference	3-82504
2.	Patent application number *(The Patent Office will fill in this part)*	24 NOV 2003 0327310.9
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	OzTech Pty Ltd as Trustee of the OzTech Trust Level 2, 8 Manukau Road, Newmarket, Auckland 1031, New Zealand.
	Patents ADP number *(if you know it)*	08759276001
	If the applicant is a corporate body, give country/state of its incorporation	New Zealand
4.	Title of the invention	Pressure Impulse Mitigation
5.	Name of your agent *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001

		Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6.	Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months			

		Number of earlier UK application	Date of filing *(day / month / year)*
7.	Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute *(see note f)*		

8. **Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request?** — Yes

Answer YES if:
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
Otherwise answer NO (See note d)

Patents Form 1/77

9. **Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:**

Continuation sheets of this form	-
Description	17
Claim(s)	1
Abstract	1
Drawing(s)	6 +6

10. **If you are also filing any of the following, state how many against each item.**

Priority documents	-
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for a preliminary examination and search *(Patents Form 9/77)*	1
Request for a substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. **I/We request the grant of a patent on the basis of this application.**

Signature **Date** 24 November 2003

12. **Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom**

Neil Campbell
020 7206 0600

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*
b) *Write your answers in capital letters using black ink or you may type them.*
c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s) of the form. Any continuation sheet should be attached to this form.*
d) *If you have answered 'Yes', Patents Form 7/77 will need to be filed.*
e) *Once you have filled in the form you must remember to sign and date it.*
f) *Part 7 should only be completed when a divisional application is being made under section 15(4), or when an application is being made under section 8(3), 12(6) or 37(4) following an entitlement dispute. By completing part 7, you are requesting that this application takes the same filing date as an earlier UK application. If you want the new application to have the same priority date(s) as the earlier UK application, you should also complete part 6 with the priority details.*

82504.622

Pressure Impulse Mitigation

This invention relates to a new material to be used as a pressure mitigant, e.g. as a protective barrier on or in place of windows. In particular, the invention relates to the use of water gels to form a material which can mitigate the consequences of an explosion.

Since the mid 1990's there has been an increase in the use of explosives by criminal organisations against civilian and military targets throughout the World. Their use results in death, injury and destruction of property and buildings. Previously, mitigation of explosion relied upon intelligence and police detection to provide warning of impending attack but recent events make it clear that intelligence and police operations alone cannot be relied upon to prevent explosions. Moreover, some explosions are caused simply by accident, e.g. gas or chemical explosions, and it would be useful if the consequences of such accidental explosions could also be minimised.

Conventional construction can give rise to buildings which will withstand many types of impact but it is still difficult to minimise the effects of explosions. Of particular importance and concern are the windows especially in high rise buildings. Windows are a major cause of trauma and injury caused by explosions; the fragmentation of pieces of glass not only causes death but many other permanent injuries such as loss of eyesight, organ trauma etc.

It is well known therefore for buildings and in particular windows to be protected against explosion damage by materials which mitigate their effects.

One option for minimising the problem of glass fragmentation utilises an adhesive film made of a polyester composite material which can be applied to the

inside of a window to contain glass fragments. Such films do not however prevent injury caused by fragments of masonry from cladding or from fragments falling from a height.

Certain other elastomeric polymer materials have been suggested for use as building cladding to prevent damage caused by explosions. The elastomer material is a highly ductile polymer that can be sprayed onto building surfaces including windows to prevent injury caused both by flying glass and masonry. The polymer employed is based on a polyurea and may be suitable for use with temporary structures as well as concrete buildings (Polymer materials for structural retrofit, Knox et al, Air Force Research Laboratory). The polymer is not transparent however and its use on windows is not desirable and experiments using the polymer have not shown a reduction in pressure effects inside a building.

There are a number of reports of conventional fire fighting foams being employed as pressure mitigants (Journal of Explosives Engineering, Vol 26, No.3, 1999). Such foams have the additional advantage of preventing fires often associated with explosions. However, the use of these foams requires that the explosive can be surrounded by the foam in a contained environment. Whilst this is possible when the source of an explosion is identified, where an explosion occurs without warning these foams cannot be used. Nor do these foams allow access to an explosive source by persons working to mitigate an accident or defuse a device controlled by criminals.

A somewhat similar system is sold under the trade name Hydrosuppressor. The system involves spraying the explosive or spraying the area in the vicinity of the explosive with water from various angles. Again however, this technique relies on the identification of an existence of a threat of an explosion prior to any explosion taking place.

A more conventional pressure protection system involves coating windows with a woven fabric mesh which acts to catch fragments of glass during any explosion. However, the mesh necessarily obscures the view through the window since it is not transparent. Moreover, the material does not cause any reduction in primary pressure within a building and hence offers no protection against direct pressure effects.

Recently, pressure impulse mitigation has been significantly improved by the use of blast net curtains and by the retrofitting of laminated glass. However, whilst net curtains provide some protection against fragmentation from glass they do not protect building integrity. Also, laminated glass cannot be used higher than about 7 storeys since it falls in total window size, i.e. does not fragment. This is potentially lethal to those in the street below.

There remains a need therefore for novel classes of pressure mitigation materials to be designed, which overcome the limitations of any of the present generation of such materials including but not limited to those described herein, and in particular to provide protection against zero warning explosions. Moreover, with the increase in criminal activity, the use of pressure impulse mitigation materials in construction may become common place and hence there remains a need to devise cheap, non-toxic materials for pressure impulse mitigation.

The present inventors have surprisingly found that mixtures of water and gels (from hereon water gels) are particularly suitable for use in barriers to prevent damage caused by explosions. The inventors have surprisingly found that water gels can be formed into structures which can withstand significant over-pressures compared with materials currently used in buildings. Without wishing to be limited by theory, it is envisaged that the inherent elasticity of the water

gel makes it an excellent material for absorbing the shockwave of an explosion. Moreover, the aqueous nature of the water gel ensures that it is also capable of resisting heat and quenching flame, in particular in the immediate aftermath of an explosion.

Thus, viewed from one aspect the invention provides the use of a water gel in pressure impulse mitigation, e.g. blast mitigation.

Viewed from another aspect the invention provides a method for protecting an entity, e.g. a structure or organism, from the effects of an explosion comprising covering at least a part, preferably all of said entity in a protective barrier comprising a water gel.

Viewed from a still further aspect, the invention provides a protective barrier comprising a water gel, wherein the concentration of gel in the water is at least 1% w/w and the thickness of the barrier is at least 5 mm.

Alternatively viewed, the invention provides a protective sheet comprising a water gel wherein the concentration of gel in the water is at least 1% w/w and the thickness of the barrier is at least 5 mm.

By pressure impulse mitigation is meant that at least one of the effects, preferably all of an explosive blast, e.g. fragmentation or collapse of buildings or glass, translation of objects within the building and primary and secondary effects of fire are reduced. A pressure proof barrier is one which does not fail when an explosion occurs or one which mitigates the level of pressure experienced by materials or an organism. An organism is a living plant or animal, e.g. a human.

By entity is meant anything which should be protected from the impact of an explosion, e.g. structures, organisms and the general physical environment

By structure is meant any inanimate object which could be protected from explosive damage such as

buildings (temporary or permanent), industrial plant, civil infrastructure, vehicles, military equipment, computers etc.

By water gel is meant a mixture of water and a gel to form a solid elastomeric barrier. The gel should preferably be non-toxic and cheap to manufacture or isolate. It should exhibit elastomeric properties, have a high elastomeric modulus and a high ductility. Suitable gels include gelatin, gellan gum gels, poly(gamma-benzyl-L-glutamate) (PBLG), agar (preferably composed of 70% agarose, a gelsaccharide and 30% agaropectin), collagen, protein gels, polysaccharides gels, keratin gels, hydrogels, ormosils (organically modified silicates often of formula $(R'_nSi(OR)_{4-n}$ in which R is typically an alkyl group and R' an organic group), sol-gels, hydrophilic polymer gels, and protein polysaccharide gels. Other suitable gels include biogels such as carrageenans, pectins, alginates (e.g. xanthan alginates casein), seed gums, egg protein g and Gelacrimide gels. Mixtures of gels can be employed.

These gels can be obtained from commercial sources. A preferred gel is gelatin.

The gelatin preferably has a molecular weight range of 20,000 to 300,000 D, e.g. 20,000 to 150,000 D and can be made from the hydrolysis of collagen.

The mixture of water and gel should comprise between 1% by weight and 25% by weight of gel, e.g. at least 1% by weight of the gel, preferably at least 2% by weight gel, especially at least 5% by weight gel, e.g. in the range 5% by weight to 10% by weight gel.

Another property of the water gel is its stress relaxation, with values in the range 0.05 to 0.3 kPa being preferred. Higher stress relaxation values indicate an increased ability to withstand impulse pressure.

Mixing of the water and gel can be achieved by any convenient means, preferably with stirring or sonication

to ensure complete mixing. Thus, the hot gel can be mixed with water in a mould and allowed to cool to form the water gel elastomeric barrier of the invention. The water used may be deionised or distilled if desired but this is not essential. Other sources of water such as tap water are also employable. The resulting mixture is suitable for use as a protective barrier.

The water gels are inherently non-flammable, cheap and non-toxic making them very attractive building materials.

The water gel mixture can be formed into sheets to provide protective barriers which mitigate the effects of explosion. There is a close relationship between the concentration of gel within a barrier, the thickness of the barrier and its pressure impulse mitigation performance. The skilled person will be able to tailor concentrations and thicknesses to prepare sheets having desired properties. However, the concentration of gel within the water gels of the invention should preferably be in the range 10 g/L to the solubility limit of the particular gel in water, e.g. 25 to 100 g/L for gelatin.

The thickness of a protective barrier or sheet may vary depending on the nature of the barrier, e.g. whether it is being used to protect windows, personnel, buildings etc. However, suitable thicknesses are in the range 10 mm to 1 m, e.g. 15 mm to 20 cm, preferably 20 mm to 10 cm.

Suitable thicknesses for sheets to be used in building cladding are in the range of 10 to 100 mm preferably 10 to 20 mm. Where the material is used to cover windows suitable thickness is in the range of 10 to 50 mm. When the material is used in clothing suitable thickness is in the range of 10 to 15 mm.

In order to protect the barrier material against degradation by, for example, bacteria or light it may be essential to mix the water gels with antibacterials (e.g. sodium azise), detergents and/or antioxidants as

additives in the water gel formulations. Other additives include colouring agents to produce a tinted product, emulsifiers, crosslinkers (e.g. methylacrilimide), photoinitiators (e.g. 1-[4-(2-hydroxyethoxy)phenyl]-2-hydroxy-2-methyl-1-propan-1-one), viscosity modifiers, organic additives (such as xanthum gum, starch), inorganic additives (such as sodium sulphate, calcium salts, magnesium sulphate, ammonium sulphate) can be employed.

Thus, the protective barrier or sheet of the invention should preferably comprise at least 50% by weight of water gel, more preferably at least 80% by weight, especially at least 90% by weight of water gel.

The protective barrier of the invention could also be employed as one layer in a multilayer material. Layers of water gel could be mixed with layers of other pressure mitigating materials to form composites. Layers of fire retardant material, layers of material impervious to chemicals or biological agents could also be added.

Such a multilayered composition could have important applications in the military and for the general public close to industrial sites such as chemical storage facilities, nuclear reactors or research laboratories or areas where transportation of hazardous materials occurs. Such compositions could be used in clothing to protect against, fire, explosion and the threat of chemical, biological or radiological contamination.

The water gels of the invention should preferably have an elastic modulus in the range of 100 to 1000 kPa, preferably 120 to 900 kPa, more preferably 300 to 800 kPa, e.g. 700 to 800 kPa.

High elastic modulus can be achieved by cross-linking the water gel mixture. Thus, for gelatin, it is within the scope of the invention to cross-link the gelatin with a cross-linking agent such as

methacrylimide.

The water gel can be formed into any suitable shape or form depending on the nature of the protective barrier desired. The water gels of the invention can be formulated into sheets using known techniques such as injection moulding or thermal cooling of the material. The width of the material will depend on the nature of the use. Thus, where the water gel is being used to prevent fragmentation of glass in a window, the water gel can be formed into a sheet for use in covering the window. The water gels of the invention may also be used as protective barriers, e.g. sheets on or within buildings or on equipment. Thus, water gel sheets could be used as building cladding, blast curtains or formed into thin sheets for covering equipment such as computers.

When used as a protective layer over building cladding, it is most important that the lower part of the building is protected from the effects of a blast. Thus, the protective water gel barrier may be adhered only to the lower part of a building, e.g. the bottom three floors since this is the area which suffers from the greatest blast impact from a ground based explosion.

The protective water gel barrier may be continued inside the building on partitions or inside walls to strengthen the structural resistance to blast. The material may also be used as a protective surface across the whole façade of a building to protect against explosive pressures from very large explosions or from air-borne contaminants from an explosion.

Water gels ~~may also~~ be formulated as protective blankets or clothing for personnel. Alternatively, very large sheets of water gel could be produced for covering critical environmental areas, e.g. reservoirs, or iconic targets. Temporary structures, in particular temporary military structures, may be covered with this material to mitigate the impact of explosions on buildings

equipment and personnel. The material could also be used as a fuselage liner in aircraft or as a liner in a vehicle.

For convenience, the material for permanent or temporary fixing across doors, windows, on horizontal or vertical surfaces etc may be in rolls that can be cut to create barriers. The material may also be extrudable.

The forming of the water gels into desired shapes can be achieved easily using known equipment, e.g. those used in the food industry to make jelly or those used in the pharmaceutical industry to make capsules.

It is also envisaged that the water gels of the invention may protect against heat, flame and fire. By definition, the water gels of the invention comprise an aqueous component. For this reason, they are capable of absorbing heat and dousing flame much more efficiently than other zero warning pressure impulse mitigation materials. It is a particular advantage of the invention that the water gel pressure impulse mitigation material simultaneously can act to protect against fire.

When exposed to heat, it is envisaged that the water gel may partially or completely melt thereby releasing water to help quench any fire. Moreover, during an explosion, the water gel may first absorb the effects of the explosive blast and heat associated therewith and subsequently melt to prevent associated fire damage. This forms a further aspect of the invention and hence viewed from a further aspect the invention provides the use of a water gel to mitigate the effects of fire.

Viewed from another aspect the invention provides a method for protecting an entity, e.g. a structure or organism, from the effects of fire comprising covering at least a part, preferably all of said entity in a protective barrier comprising a water gel.

The water gel barriers of the invention may also serve to protect organisms against flame burns from

secondary contact with hot objects or large fire. A skin temperature of 70°C will produce the same type of burn as exposure to 48°C for a few minutes. Skin burns under clothing depend on the colour, thickness and nature of the fabric and if the fabric ignites. Research has suggested that burns were more severe where an individual wore dark clothing than white clothing because of the reflection of heat by white and light fabrics. In this embodiment the water gel could be combined with a thermal insulating layer to prevent heat transfer to the skin.

It is believed that the water gel barrier of the invention may also act as a heat reflector as well as an absorption agent and thus protect against flame burns.

The water gel barriers of the invention may also help in the event of a conventional fire, particularly in a building in which the external structure is predominantly made from glass. During a fire in such a building, the metal frame of the building tends to expand and the windows can therefore fall out of their frames. The presence of a water gel will slow down any expansion of the building frame thereby allowing firefighters more time in which to control the fire.

The water gel would also act as a heat reducer in wooden buildings.

The water gels of the invention are more effective at mitigating the effects of fire at lower gel concentrations, i.e. higher water concentrations. However, the water gels are more effective at pressure impulse mitigation at higher gel concentrations. It is therefore within the scope of the invention to provide a multilayer barrier comprising water gel layers having varying gel concentrations to provide barriers tailored to mitigate the effects of both fire and pressure.

The material of the invention may also provide a barrier to chemical or biological contamination, e.g. as the result of a criminal attack or chemical leak. The

surface of the water gel material is inherently sticky and hence biological and chemical compounds may attach to the surface of the material thereby preventing further contamination taking place. Additionally the water gel material acts as a barrier that, unlike most open weave material, prevents biological materials under the size of 5 microns from passing through to the surface of a material below.

The water gels may also have applications in environments where sterility is required, e.g. in hospitals or laboratories. The water gel could aid in preventing infection e.g. when used as a coating agent in a treatment room which can easily be removed and replaced when necessary.

The water gel material may also act as a barrier to alpha and beta particles of radiation that may be present in sources used in industry and in weapons used by the defence forces. Research from Japan has shown that the effects of thermal radiation are reduced by up to 50% by clothing acting as a barrier to radiation. If beta particle emitters come into contact with the skin a beta burn may result and the water gels of the invention may prevent this occurring.

The effects of radiation were observed in Japan and in the Marshall Islanders in 1954 (Source of case studies in Japan and Marshall Islands, Glasstone and Dolan, The effects of nuclear weapons, US Dept. of Defence pubd 1977 ed). Alpha emitters and beta particles can deposit their entire energy within a small sensitive volume of the body tissue causing damage. Particles of greater than 10 micrometers are filtered out by the nose and 95% of 5-10 micron particles are also filtered but the very fine particles under this size reach the lungs causing internal body damage. Alpha particles can be retained in the lungs for a long time and can cause serious injury to lung, liver and bone. In the Marshal islands studies much of the

material contaminated food, water, utensils and other objects in the environment.

Because radiological sources are present in hospitals and industrial locations and are also sought for criminal use, widespread contamination of the environment as well as body effects on people and other organisms is possible.

Currently available biological/radiological masks that have been produced for protection against viruses and organisms such as anthrax are constructed to transmit only particles of under 5 microns when the person is breathing. Special filters are also used for heavy contamination situations, e.g. charcoal which absorb or physically hold the hazard so that it does not reach the person's airway. The water gels of the invention may act as a further physical barrier for use in masks.

Moreover, if a water gel layer was combined with, for example, a boron layer a broader range of radiological effects could be preventable. Thus, gamma radiation or neutrons could be absorbed by a water gel barrier comprising a boron layer.

Water gel sheets also provide the added advantage that post contamination clean up is made much simpler. Since the chemical or biological agent may stick to or dissolve within the water gel, clean up can be effected simply by removing the water gel sheet from the structure in question. This forms a further aspect of the invention and hence viewed from a further aspect the invention provides the use of a water gel to protect entities, e.g. structures or organisms against chemical, biological or radiological contamination.

The material may also be used to mitigate contamination after an incident by being applied as a decontamination material, e.g. by unrolling sheets of the material down roads or surfaces.

In some applications there may be several layers to

provide various protections from heat and blast with an optional top layer being a throw away contaminatable layer.

It is a particular advantage of the material of the invention that it is transparent and hence does not affect the amount of light entering a building when used as a window protector or affect the external appearance of a building when used as a cladding.

Fixing the material to a structure can be achieved using conventional techniques. For example, for window protection, the material may be adhered to the window surface (inside and/or outside) using known adhesives such as ceramic bonds or other bonding materials that adhere to wood, concrete or glass surfaces. These materials are readily available through suppliers to dentists for bonding of ceramic veneers to teeth, and in the construction industry for bonding materials together.

It is particularly advantageous if the bond between the water gel sheets and the window is stronger than the fixing holding the window frame into the wall.

Within clothing or where sheets are being bonded together to create large surface areas for protection the use of these industrial bonding agents may create seams that should be stronger than the water gel material and protect large surface areas from the pressure of being split at the seams.

The material could be placed in wall cavities or roof space or secured to the outside of a building by adhesives or in a frame. The person skilled in the art can devise alternative methods of fixation.

Other forms of encapsulation of layers of the water gel material may involve vacuum sealing and the use of hydrostatic films as is known in the art. The gels may be acidic or basic giving rise to further options for fixation.

The invention will now be further described with

reference to the following non-limiting examples and Figures 1 to 6.

Brief Description of the Figures

Figure 1 shows the boundary between failure of the barrier where pressure on one side of the barrier is transferred at a reduced level to the other side of the barrier and those that remained intact where the pressure is retained on one side for the barriers employed in example 1.

Figure 2 shows typical pressure curves for a barrier that fails. The pressure at failure was 18.6 kPa. The thickness of the gel was 15 mm at a concentration of 40g/l. Even though the gel failed, the over pressure is markedly reduced outside the barrier. The magnitude of this reduction increased as the concentration of the gel was increased.

Figure 3 shows the results of an experiment in which the barrier has a concentration of 90 g/l and is 20 mm thick. The barrier survived the pressure and hence the pressure gauge a P2 is flat.

Figure 4 shows a displacement and overpressure curve for a 20 mm, 40 g/L gelatine barrier. Significant elongation of the barrier occurred but the barrier remained intact.

Figure 5 shows a displacement and overpressure curve for a 20 mm, 90 g/L gelatine barrier. This barrier also remained intact. The deflection of the barrier is less because of the increased stiffness in the barrier.

Figure 6 is a graph of modulus vs gel concentration for the results presented in Example 2.

Example 1

The apparatus employed in the example is shown in Scheme 1. It consists of a 100 mm by 50 mm duct, 2.5 m in length, closed at one end. The gel layer was placed in a holding frame between the open end of the duct and an extension of the duct.

The enclosed portion of the duct (approx 12.5 L) was filled with a 4.3% propane in air mixture and allowed to recirculate for a few minutes prior to igniting the gas with a spark plug. The pressures on either side of the barrier were measure at P_1 and P_2. The displacement of the gelatine gels were captured using a Phantom High Speed Video Camera. The independent variables were the thickness of the layer (d), and concentration of gel (n).

Gels were made up by mixing an appropriate amount of gelatine obtained from commercial suppliers and tap water. The water gel was formed into a barrier by pouring a hot solution of the gel into a mould and allowing this to cool. The moulded gel was inserted in a holding frame between the duct and a duct extension and secured in place by screwing the extension duct onto the main duct.

The frame thickness was slightly less (approximately 1mm) than the gel thickness. In screwing the extension duct onto duct slight compression of the gel occurred giving a gas tight seal between the duct and the extension duct.

Results

Table 1 is a summary of the experiments. Generally those gel barriers with a thickness below 15 mm broke when subjected to the overpressure generated by the propane ignition. Figure 2 which shows the relationship between thickness, concentration and outcome suggests

that thicknesses as low as 12 mm would survive this explosion overpressure at higher concentrations. All those at higher concentrations survived the overpressure impulse.

Table 1

Thickness	Concentration	Outcome
mm	g/L	
15	6	Failed
5	10	Failed
10	10	Failed
15	10	Failed
20	10	Failed
25	10	Failed
15	12	Failed
15	14	Failed
15	40	Failed
10	54	Failed
10	70	Failed
17	40	Intact
20	40	Intact
20	54	Intact
15	70	Intact
15	90	Intact
20	90	Intact

The highest concentration of gelatine employed in Example 1 survived pressures of 65kPa. Threshold values for glass breakage are of the order of 1.5KPa while cladding on buildings collapses at 30 KPa. Domestic buildings in the UK and US are totally destroyed at about 70kPa.

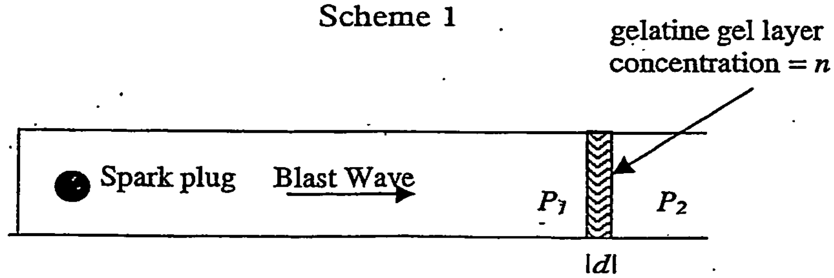
Example 2

A series of further water gels were prepared as per Example 1. The thickness of the water gel was 20 mm with a varying concentration. The elastic modulus of each gel was measured by a texture analyser in which the strain of the gel was kept constant while change in stress was recorded. The maximum stress is shown in Table 2.

Table 2

Gel Concentration(g/L)	Modules (kN/m2)
8	44.0
10	80.3
40	326
54	383
70	690
90	784

Scheme 1



Claims

1. Use of a water gel in pressure impulse mitigation, e.g. blast mitigation.

2. Use as claimed in claim 1 wherein said water gel is formed from gelatin and water.

3. A method for protecting an entity, e.g. a structure or organism, from the effects of an explosion comprising covering at least a part, preferably all of said entity in a protective barrier comprising a water gel.

4. A protective barrier or sheet comprising a water gel, wherein the concentration of gel in the water is at least 1% w/w and the thickness of the barrier is at least 5 mm.

5. A method for protecting an entity, e.g. a structure or organism, from the effects of fire comprising covering at least a part, preferably all of said entity in a protective barrier comprising a water gel.

Abstract

Pressure Impulse Mitigation

This invention concerns the use of water gels, i.e. mixtures of gels and water in pressure impulse mitigation, e.g. blast mitigation. Such water gels have been found to resist over pressures and being aqueous also have applications in the prevention of fire.

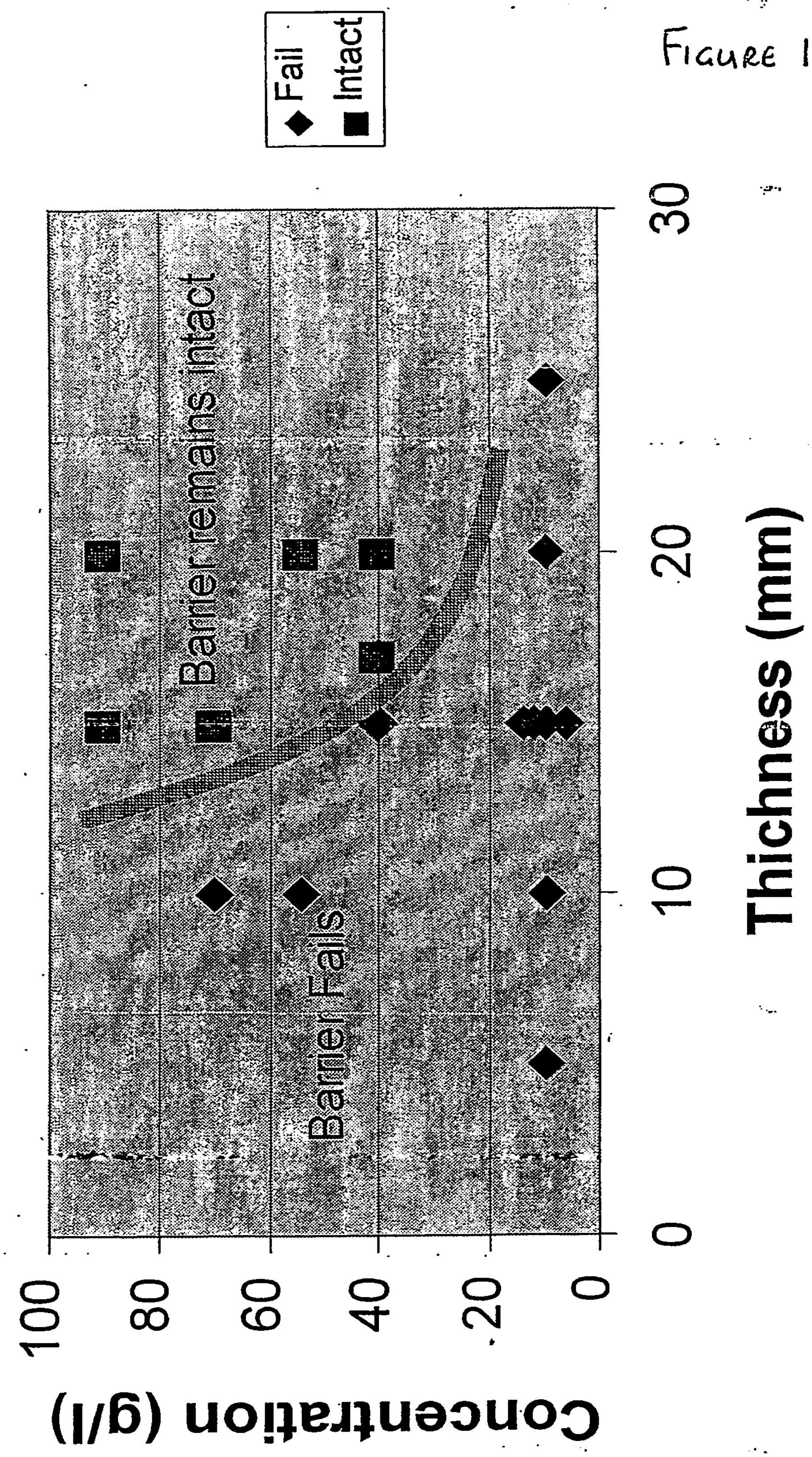

Fail
Intact
Barrier remains intact
Barrier Fails
Concentration (g/l)
0
20
40
60
80
100
0
10
20
30
Thichness (mm)

Figure 1

Fig. 2

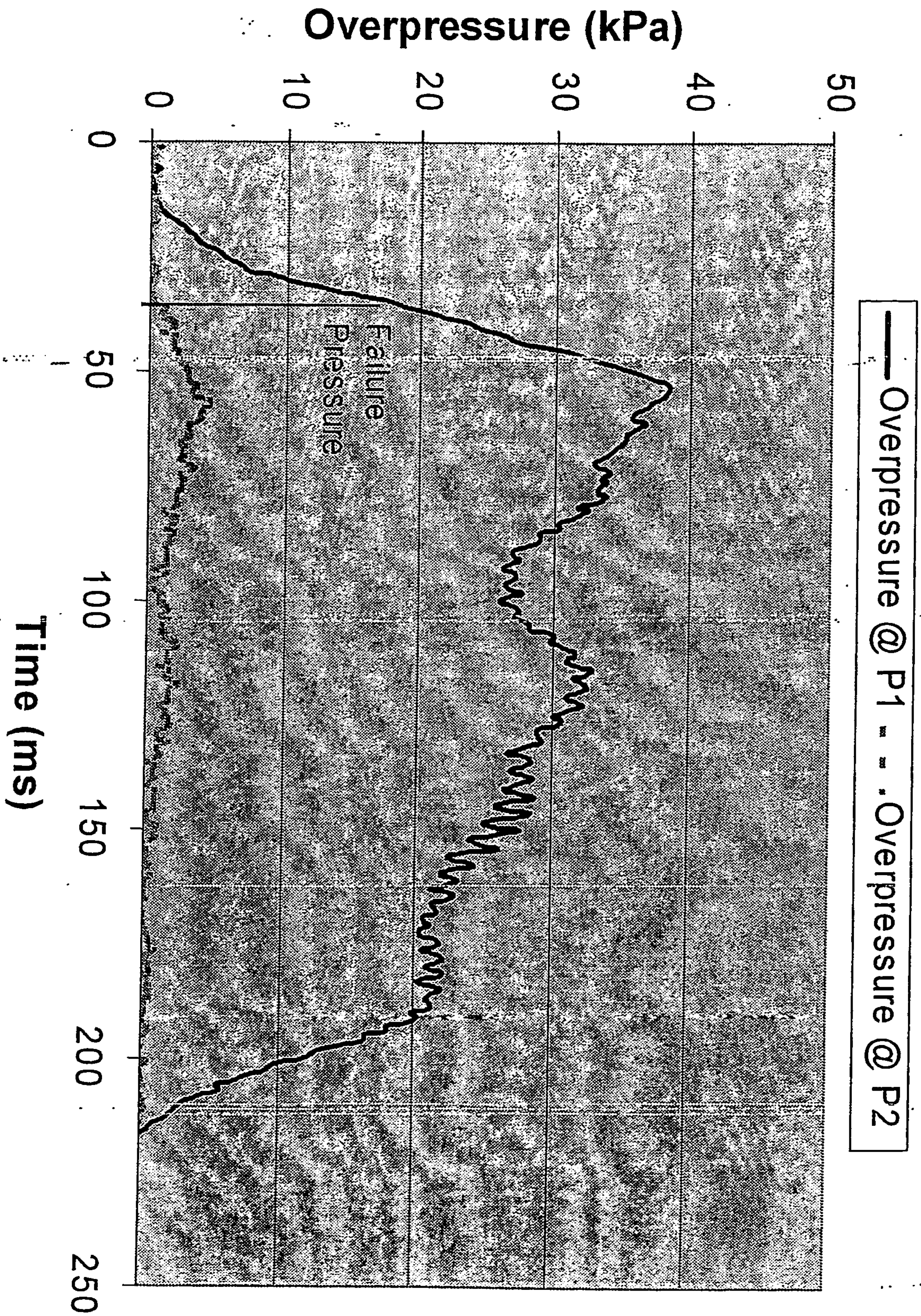
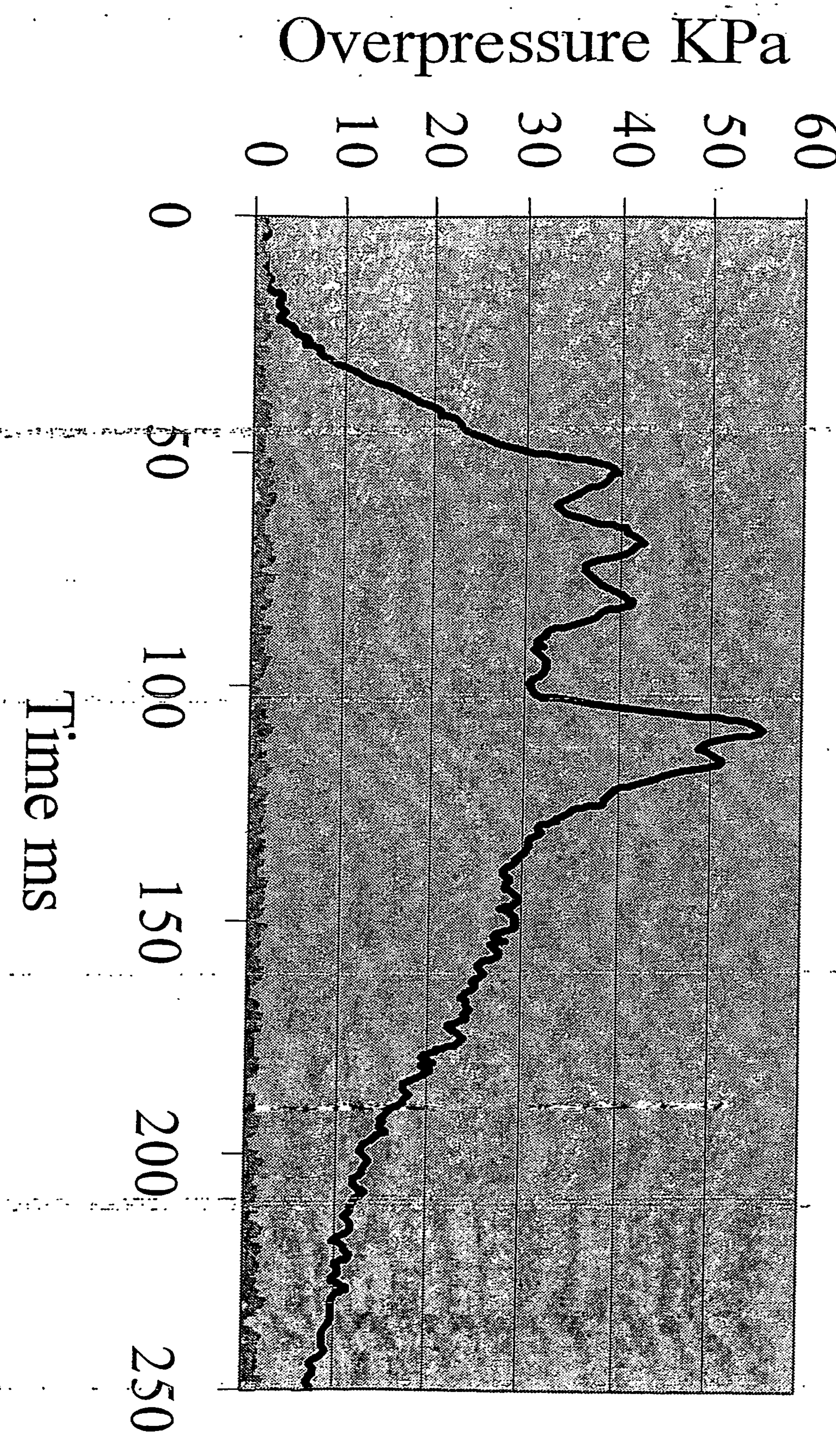
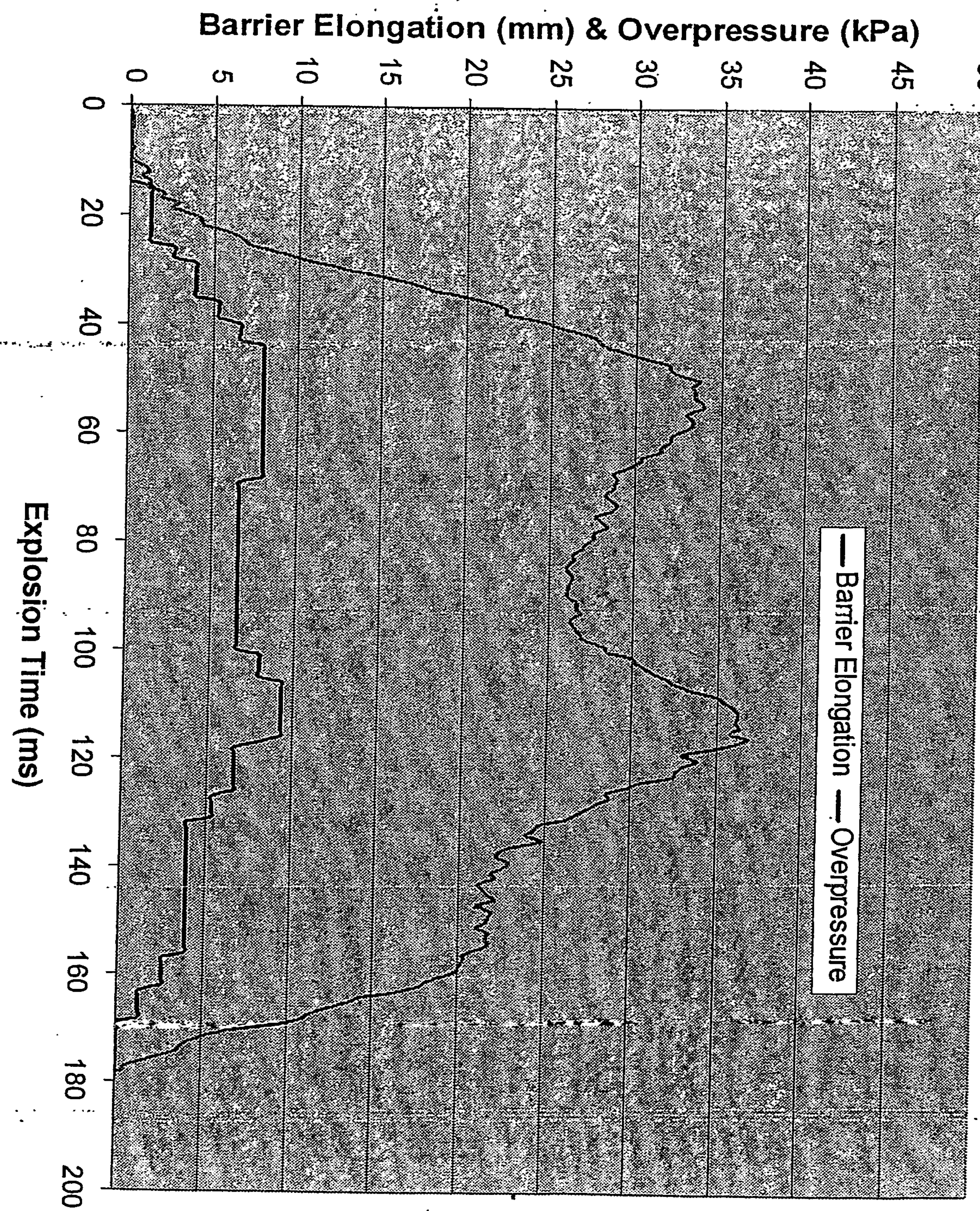

Overpressure (kPa)
0
10
20
30
40
50
Time (ms)
0
50
100
150
200
250
Failure Pressure
Overpressure @ P1
Overpressure @ P2

FIG 3 3/6



4/6

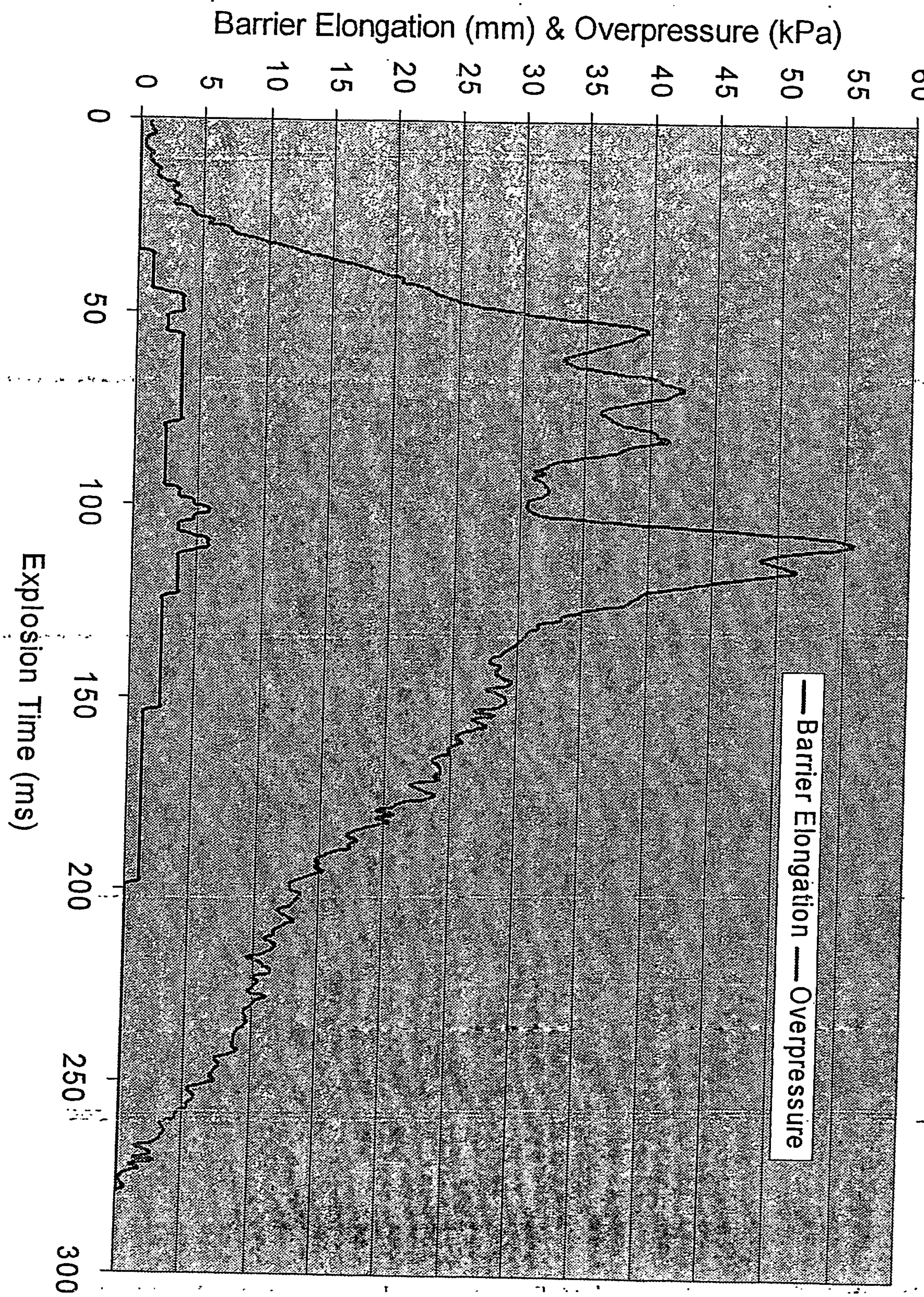
FIG 4



Barrier Elongation (mm) & Overpressure (kPa)
0
5
10
15
20
25
30
35
40
45
50
Explosion Time (ms)
0
20
40
60
80
100
120
140
160
180
200
Barrier Elongation
Overpressure

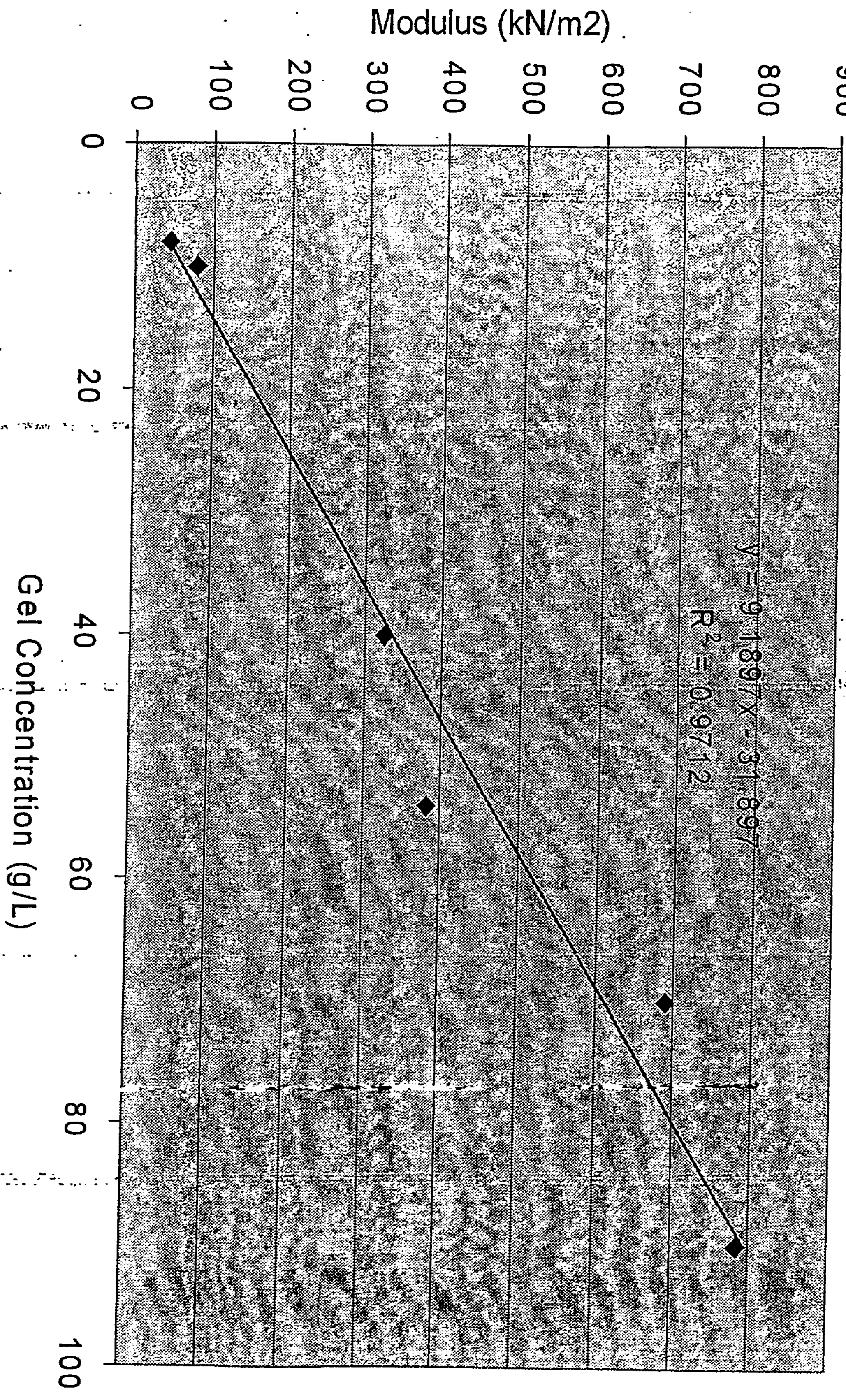
5/6

FIG 5



Barrier Elongation (mm) & Overpressure (kPa)
0
5
10
15
20
25
30
35
40
45
50
55
60
Explosion Time (ms)
0
50
100
150
200
250
300
Barrier Elongation
Overpressure

6/6 FIG 6



Modulus (kN/m2)
0
100
200
300
400
500
600
700
800
900
0
20
40
60
80
100
Gel Concentration (g/L)
y = 9.1897x - 31.897
R^2 = 0.9712

Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/GB04/004952

International filing date: 24 November 2004 (24.11.2004)

Document type: Certified copy of priority document

Document details: Country/Office: GB
Number: 0327310.9
Filing date: 24 November 2003 (24.11.2003)

Date of receipt at the International Bureau: 28 February 2005 (28.02.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)